A Spectrographic Study of the Fourth-Class Variable Stars *Y* Ophiuchi and *T* Vulpeculæ.[1]

Introduction.

On account of the extremely small displacements of spectrum lines, due to the radial velocities of the stars, it is desirable to use spectrographs of as high dispersion as possible. The amount of star-light available is the principal factor in determining the upper limit of the dispersion. At present, determinations of the radial velocities of stars are made most extensively with three-prism instruments. These can be made to yield velocities reliable within a few tenths of a kilometer. The practicable limit of such an instrument, attached to the largest existing telescopes, is about the sixth photographic magnitude, which requires an exposure of approximately two and a half hours. There is urgent need for a knowledge of the radial velocities of much fainter stars. Data for the solution of important astronomical problems by non-spectroscopic methods have been obtained from a large number of stars, some of which are as faint as the twelfth visual magnitude, whereas radial velocities have really been limited to the sixth photographic magnitude. The one-prism spectrograph of the Lick Observatory was employed by Dr. R. H. Curtiss in a study of the variable star *W Sagittarii*,[2] which varies between 5.5 and 6.5 photographic magnitudes. His work showed that good velocity determinations with the one-prism instrument could be obtained, at least when the exposures were comparatively short. His average exposure was about thirty minutes. It was definitely an object of the present investigation to test the efficiency of this spectrograph for much fainter stars, requiring long exposures. The average exposures for the two variable stars selected (*T Vulpeculæ* and *Y Ophiuchi*) were 75^m and 180^m, respectively. The latter star, of about the eighth photographic magnitude at minimum, may be considered the practicable limit for this instrument, attached to the 36-inch refractor. In the case of a star whose light is concentrated in a few spectrum-lines or bands, it is of course possible to go

[1] Thesis in partial fulfilment of requirements for the degree of doctor of philosophy in the University of California. A more complete account is published in *Lick Observatory Bulletin*, No. 118, and in the *Astrophysical Journal*, Vol. XXV, 330, 1907.

[2] *L. O. Bulletin*, No. 3, 19, 1904; and *Astrophysical Journal*, Vol. XX, 149, 1904.

several magnitudes lower. For example, the spectrum of *Nova Aquilæ* No. 2 was successfully photographed when the star was of the eleventh visual magnitude.

The dispersion of the one-prism spectrograph is one fifth that of the three-prism Mills spectrograph. The average radial velocity of the brighter stars is about $\pm$ 20^{km} per second. The equivalent displacement with the one-prism instrument, for the Hγ region, is 0.005^{mm}. A radial velocity of 2^{km} would produce a shift of 0.00002 inch (0.0005^{mm}). If the average radial velocity for the fainter stars is about the same as for the brighter, then these small displacements are the quantities to be measured on the plates taken with the one-prism spectrograph. The results obtained are considered highly satisfactory. In the case of *Y Ophiuchi,* with an average exposure of three hours, the double amplitude of the velocity-curve is only 17^{km}. On the Mills spectrograms the same linear displacements would give a curve of 3½^{km} double amplitude.

In addition to testing the possibility of extending the usefulness of the one-prism instrument for radial velocity work, it was thought that a contribution might be made toward the discovery of the causes of some of the peculiarities that are observed in short-period variable stars of the *δ Cephei* or *η Aquilæ* type. Some of the more important points to be considered in this connection are: The peculiarities of, and the relation between, the light- and velocity-curves, peculiarities of the spectrum, changes in the character of the spectrum during the period of variability, and the behavior of the individual spectrum-lines.

A Peculiarity of the Spectra.

In the variable stars of the *δ Cephei* type there is a greater richness of photographic radiation relatively to visual radiation at light-maximum than at light-minimum.[1] During the light-period the point of maximum energy on the energy-curve shifts along the spectrum, moving toward the shorter wave-lengths as the star approaches light-maximum, and back again toward the longer wave-lengths as light-minimum is approached. This fact is to a certain extent masked upon the spectrograms by

[1] The observations by WILKENS confirm this point. For five stars he finds the photographic range of brightness to be about one half greater than the visual range. —*Astronomische Nachrichten,* Vol. CLXXII, 305, 1906.